1.0 INTRODUCTION

This ordnance and explosives (OE) remedial design document (RDD) describes the methods and procedures used to locate and remove OE and eliminate exposure pathways to OE at the Tourtelot Remediation Project Site, Benicia, California. The OE RDD is one of a series of documents and/or actions in response to the Imminent and/or Substantial Endangerment Determination and Remedial Action Order (Docket No. I/SE 98/99-011), signed June 1, 1999 (the "Order"), issued for the Project Site by the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC). A draft final remedial investigation (RI)/feasibility study (FS) report was prepared that presented the results of the soil, surface water, and groundwater sampling and analysis activities; a summary of OE investigations performed to date; and additional data gathered regarding the extent of OE at the Tourtelot Project Site. The draft final RI/FS report also developed and evaluated alternatives for the remediation of both OE and chemically affected soil at the site. This OE RDD describes how Alternative 5, the recommended alternative, of the draft final RI/FS report will be implemented with regard to OE cleanup.

The Tourtelot Project Site is in the City of Benicia, Solano County, California, approximately 30 miles northeast of San Francisco (Figure 1-1). The Project Site, which includes a portion of the Unit D-1 fill that extends onto the adjacent Valero property, and the extension of TNT Strips into the City of Benicia property are referred to in this OE RDD as the "Project Site" (Figure 1-2). The Project Site has rolling topography that includes areas referred to as the North Valley and the South Valley; it is bordered by the Southampton residential development to the west and south, industrial and commercial facilities to the east and south, and open space to the north. The Tourtelot Remediation Project proponents are Granite Management Corporation (Granite), who is the current owner of the Project Site, and the U.S. Army Corps of Engineers (USACE).

When investigating sites that may contain OE, unexploded ordnance (UXO), and OE scrap (inert and nonhazardous), the Department of Defense (DOD) often intends the term "OE" to be inclusive of all ordnance items that may be found at a site. The terms used in this document are defined below:

(1) Ammunition, ammunition components, chemical or biological warfare material or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired. Such ammunition, ammunition components, and explosives are no longer under accountable record control of any DOD organization or activity (Headquarters, Department of the Army Policy Memorandum, "Explosives Safety Policy for Real Property Confirming Conventional OE").

(2) UXO, military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material and remain unexploded either by malfunction, design, or any other cause (Military Munitions Rule, 40 Code of Federal Regulations [CFR] Part 266.200).

(3) Explosive soils (mixtures of explosives in soils, sand, clay, or other solid media) at a concentration (10 percent or above by weight) such that the mixture itself is explosive (U.S. Army Corps of Engineers, 2000).

(4) OE scrap includes those items that are fragments of functioned ordnance, as designed or intentionally destroyed, and that contain no explosive or other items of a dangerous nature. OE scrap is inert and does not pose a safety risk (U.S. Army Engineering and Support Center, 1998a).

(5) OE-like item has a similar geophysical signature to an OE item (Personal Communication, Austreng, 2001).

Based on historical research and OE cleanup operations to date, it has been established that the OE at the Project Site did not originate from artillery firing or bombing range activities, but from demilitarization activities restricted to specific areas of the former arsenal locations where demilitarization activities are reported to have occurred. Therefore, UXO is not expected to be found on the Project Site. Suspected demilitarization areas are shown on Figure 1-3.

1.1 REMEDIAL DESIGN GOALS AND OBJECTIVE

The objectives of the project are as follows:

- Remediate the Project Site in a manner and to standards that would allow DTSC to determine that all appropriate response actions have been completed and that no further removal/remedial action is necessary for the Project Site under the Order issued by DTSC on June 1, 1999 (Docket No. I/SE 98/99-011).

- Remediate the areas of the Project Site that are zoned for residential use to a standard suitable for unrestricted residential use.

- Remediate the other areas of the Project Site to a standard suitable for open space use consistent with the City of Benicia General Plan (City of Benicia, 1999) and Zoning Ordinance (City of Benicia, 1987). Copies of the City of Benicia General Plan and Zoning Ordinance can be obtained by contacting the City of Benicia Planning Department.

In order to meet these project objectives, the Tourtelot Remediation will include remediation of OE and the identification, characterization, treatment, and

removal of soil containing chemical concentrations exceeding remedial action objectives (RAOs), as detailed in the Remedial Action Plan (RAP). Two RDDs have been prepared detailing the remedial design to achieve these objects, this document for OE remediation and one for remediation of chemically affected soils. Broadly, the OE site remediation will consist of several coordinated activities:

- Point clearance of OE, OE scrap, and non-OE metallic debris from the entire site

- OE clearance of chemically affected soil requiring off-site disposal to determine that it is free of OE

- Homogenization, excavation, and stockpiling of TNT-affected soil with TNT concentrations of 10 percent or more by weight (as measured prior to homogenization),

- Areawide clearance in order to assure clearance of OE from areas that are planned for future residential use in the South and North Valleys and on the Ridge, the area between the North and South Valleys.

The goal of the OE remedial design is to identify and remove OE and OE scrap from the Project Site, and to eliminate potential risk that OE poses to human health and the environment. This OE RDD meets the requirements of Section 5.11 of the DTSC Order, which include:

- Specific criteria to be used in deciding whether to blow in place (BIP) or move the OE for on-site disposal, including the potential for impacts to the surrounding neighborhoods, schedules of the activities (digging/BIP), and duration.

- A geophysical mapping plan addressing geophysical data collection, data processing, preparation of maps and dig sheets, and reacquisition and marking of anomalies.

- Design criteria and process diagrams for the Project Site.

- A description of equipment used to excavate, handle, and transport OE.

- A field sampling plan addressing sampling for achievement of the performance objectives for the OE removal action.

- Identification of any necessary permits and agreements.

- A schedule for implementing the proposed OE point and areawide clearance actions to the extent that areawide clearance can be identified.

The objective of the OE remediation is to remove OE, OE scrap, and metallic debris, thus eliminating any potential pathway for OE exposure. OE remediation will be implemented in three phases. The first phase will identify and remove detected OE, OE scrap, and metallic debris through completion of a point clearance, as defined below. The second phase entails an areawide clearance operation that will remove soil that has been point cleared from areas that contained OE or have the potential to contain OE and placing the soil as engineered fill in the North Valley. The determination of whether soil meets the criteria for areawide clearance will be based upon the evaluation of the distribution of OE and OE scrap removed in Phase 1. The third phase involves grading of the site to establish a minimum of 14 feet of OE-free crushed bedrock over the areawide cleared soils.

At the conclusion of the fieldwork, an OE Project Closure Report documenting implementation of the OE RDD and an Operation and Maintenance Plan will be prepared and submitted to agencies. The OE remediation schedule is included as Appendix A.

1.2 COMMUNITY OUTREACH/PUBLIC PARTICIPATION

The adjoining community and other interested parties will be informed of the activities conducted at the Project Site, in accordance with the Public Participation Plan (PPP) and the final Minimum Separation Area (MSA) Notification and Implementation Plan (MSAP). Public meetings will be held and fact sheets prepared as major milestones in the OE removal/remediation are achieved, in accordance with the PPP for the Project Site (Granite Management Corporation, September 1999). The process for providing information to the community, including public meetings, is described in the MSAP (Appendix B).

1.3 REGULATORY OVERSIGHT

On June 1, 1999, DTSC issued an Order stating that removal and remedial action are necessary at the Project Site because there may be an imminent or substantial endangerment to the public health or welfare or to the environment. The DTSC is the lead agency overseeing the investigation and remediation of the Project Site.

It is intended that work being performed under the Order will be consistent with, and based on, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S. Code [U.S.C.], 9601 et seq.), as amended; the National Hazardous Oil and Substance Pollution Contingency Plan (NCP) (40 CFR Part 300), as amended; the Health and Safety Code (H&SC) Section 25300 et seq., as amended; state laws and regulations, as amended; and other current and applicable Environmental Protection Agency (EPA) and DTSC guidance and standards.

The Superfund Amendments and Reauthorization Act (SARA) requires that remedial actions at federal Superfund sites achieve a cleanup level that protects human health and the environment. In addition, cleanups must attain “legally

applicable or relevant and appropriate" requirements (ARARs) that are promulgated under federal or state law, unless a waiver is warranted. Although the Project Site is not a Superfund Site, the concept of ARARs has been used to evaluate and select final remedial actions for the proposed future residential and open space use of the Project Site. In addition, the work being performed will be consistent with the following DOD guidance and standards.

- Ammunition and Explosives Safety Standards, Department of Defense, DOD 6055.9.STD
- Accident Reporting and Records, U.S. Army Corps of Engineers Supplement I to AR 385-40
- Safety and Health Requirements, U.S. Army Corps of Engineers, EM 385-1-1
- Ordnance and Explosives Response, U.S. Army Corps of Engineers, EM 1110-1-4009
- Establishing and Maintaining Institutional Controls for Ordnance and Explosives (OE) Projects, U.S. Army Corps of Engineers, EP 1110-1-24
- Explosives Safety Program, U.S. Army, AR 385-64.

The following local, state, and federal agencies have jurisdiction over remedial activities at the Project Site:

- California DTSC (the lead regulatory agency for investigation and cleanup of the Project Site)
- USACE (issuance of a Section 404 permit for filling of 0.093 acre of wetlands in the North Valley and 0.206 acre of seep wetlands on the north slope of the South Valley)
- U.S. Fish and Wildlife Service (USFWS) (endangered species consultation if required by Section 404 permit)
- California Department of Fish and Game (CDFG) (issuance of a Section 1603 stream bed alteration agreement may be required. The water body in the South Valley does not appear to meet the definition of a stream because it does not exhibit a well-defined stream bed and a bank, rather, it supports characteristics of a wetbed rather than a stream)
- Bay Area Air Quality Management District (BAAQMD) (responsible for protection of air quality)

- California Occupational Safety and Health Administration (Cal/OSHA) (has oversight authority for worker protection during removal activities)

- California Regional Water Quality Control Board (RWQCB) (has responsibility for protection of groundwater and surface water quality)

- City of Benicia (has authority to issue grading and zoning permits and/or special use permits for grading and fire code permits for explosives storage for the Project Site)

- Solano County Department of Environmental Management (has authority to issue well permits and oversee underground storage tank [UST] removals).

1.4 ORDNANCE AND EXPLOSIVES SAFETY ISSUES

OE has been found on the Project Site. Soils containing trinitrotoluene (TNT) or TNT degradation products at concentrations greater than 10 percent have been identified on the Project Site. Nine live OE items have been removed from the Project Site. Soils containing explosives or undiscovered OE may present a hazard to the public. Currently, the Project Site is fenced, and security guards/patrols are maintained, which limit public ingress to the Project Site. An Explosives Safety Submission (ESS), which summarizes OE safety issues for the site, has been prepared (Appendix C).

1.5 BACKGROUND

Information presented in these sections was taken from the *Archives Search Report* [ASR] *Findings, Benicia Arsenal, Benicia, Solano County, California* (U.S. Army Corps of Engineers, St. Louis District, 1994a); *Supplement to the March 1994 Archives Search Report for Benicia Arsenal, Benicia, Solano County, California* (U.S. Army Corps of Engineers, St. Louis District, 1997); *Environmental Assessment, Benicia Arsenal Site Investigation, Benicia, California* (U.S. Army Corps of Engineers, Sacramento District, 1997); *Final Benicia Arsenal Records Research Report* [RRR] (Jacobs Engineering, 1999); *Final Engineering Evaluation/Cost Analysis [EE/CA], Former Benicia Arsenal, Solano County, California* (U.S. Army Engineering and Support Center, Huntsville, 2000); and the draft final RI/FS report (Earth Tech, 2001).

1.5.1 Site Topography

The Project Site is situated in a hilly area dominated by a central, east/west-trending ridge (referred to in this OE RDD as the “Ridge”) (see Figure 1-3) that acts as a drainage divide between a major drainage swale to the south, referred to as the South Valley, and a smaller drainage swale to the north, referred to as the North Valley. Project Site elevations range from approximately 60 feet to 300 feet above mean seal level (MSL) in the South Valley and 110 feet to

260 feet above MSL in the North Valley. The top of the Ridge, which was excavated as part of previous grading activities, is approximately 230 feet above MSL toward the east end and approximately 260 feet above MSL toward the west end. The maximum current elevation on the ungraded western portion of the Ridge is approximately 300 feet above MSL.

1.5.2 Geologic Conditions

The bedrock at the Project Site, as observed in test pits, soil borings, and geophysical investigation throughout the area, is weathered and fractured and consists mostly of claystone with various interbedded deposits of sandstone and siltstone. Bedding units generally strike to the northwest and dip to the south.

Quaternary alluvium is present in the bottom of the North and South Valleys. The total thickness of the alluvium in the North Valley is as deep as 30 feet. Various amounts of colluvium blanket the slopes of the hills. The colluvium is generally a silty or sandy clay and ranges in thickness from a few feet to more than 12 feet.

Investigations at this site reveal that the depth to weathered bedrock ranges from approximately 2 to 11 feet below ground surface (bgs) on the south slope of the South Valley, while the depth to weathered bedrock ranges from approximately 8 to 10 feet bgs on the north slope of the South Valley. The shallow soil depths on the north slope were found at the top of the slope. The alluvium in the South Valley floor is interpreted to attain depths of up to 15 feet and probably consists of fat clay, which includes weathered fragments of shale, siltstone, and sandstone.

1.5.3 Environmental Resource Data

Environmental resource data are provided in the draft environmental impact report (EIR). The draft EIR describes the plant and animal resources present at the Project Site. The majority of the Project Site is covered with nonnative annual grassland vegetation. The hillsides, ridgetops, and some of the valley floor areas of the Project Site are dominated by weedy introduced plant species. The unnamed creek that crosses the south portion of the Project Site (South Valley) supports both willow riparian and freshwater marsh vegetation/habitat. Wetlands vegetation is present in creek and seep areas on the hillsides.

1.5.4 Past Land Uses

The previous military uses of the Project Site are depicted in Figure 1-3. 2,4,6-TNT was laid out in strips (TNT Strips) along the hillside and may have been burned. Approximately 3.5 acres in the North Valley were developed with roads and structures where the accuracy of howitzer gun barrels was checked (Howitzer Test Facility), and ordnance was inspected and renovated, and primers were destroyed in a “squirrel cage” (Ammunition Renovation/Primer Destruction Site). There was also a disposal area referred to as the “North

Valley Military Landfill" in the North Valley. Part of the Ridge was reportedly used to dispose of aged, out-of-service dynamite (Dynamite Burn Site).

In the South Valley, there was a Flare Site and three suspected demolition sites (Demolition Sites #1, #2, and #3). (As discussed in Section 1.5.4.8, Demolition Site #2 is no longer considered to have been used as a demolition site.) The Flare Site was used to burn old, out-of-service flares. Demolition activities generally consisted of placing various amounts of out-of-service munitions in a "pit," placing a countercharge on top of the items, and detonating them.

1.5.4.1 TNT Strips.

The TNT Strips are visible on the hillside to the north of the North Valley, as evidenced by a lack of ground cover and soil analytical testing results. The strips are clearly visible in a December 1947 aerial photograph, but are not visible in a January 1945 aerial photograph. Historical records do not indicate when actual TNT destruction operations took place, nor do they indicate the method of destruction. There are five strips and one suspected strip. The identified strips vary in length from approximately 100 feet to 800 feet; each is approximately 6 feet wide. Exposed soil along the strips is characterized by a deep red color with crystalline materials observed in the dry season. It has been assumed that the burning of explosives, similar to that reported for the Dynamite Burn Site, resulted in the TNT Strips on the hillside above the North Valley.

1.5.4.2 Howitzer Test Facility.

The Howitzer Test Facility consisted of four structures in the North Valley. The first structure, Building 181, consisted of two parallel concrete tunnels constructed in 1945 on an excavated pad into the northeast-facing flank of the Ridge; each had a 10-foot by 10-foot opening and extended approximately 100 feet toward the hillside. The concrete tunnels were oriented approximately north-south and were partially covered with soil. The second structure, Building 182, contained the open test firing butts and was also constructed in 1945, in the middle of the North Valley, at the base of the southwest-facing hillside, approximately 450 feet north of the entrance to the tunnels. The third structure, Building 183, was a concrete powder loading room constructed in 1945, immediately west of the test firing butts. The fourth structure consisted of two buildings (Buildings 540 and 542) and included another unidentified structure. This structure was situated between the firing butts and the test tunnels. Reportedly, the buildings, which were built in 1957 (Building 540) and 1958 (Building 542), had several uses after the Howitzer Test Facility ceased operations. Building 540 was 12 feet by 20 feet, but no records of the size of Building 542 are available. None of the buildings is present on the site today.

The tunnels and firing butts were used to test howitzer barrels and propellant by firing various-sized howitzer projectiles filled with concrete or gravel into the gravel-filled tunnels. This was performed in order to determine if the barrels functioned correctly and whether the propellant was the right mixture. Gravel was dropped into the tunnels from two gravel fill ports, one on top of each

tunnel. The gravel was used to absorb the howitzer rounds fired into the tunnels. The facility was in operation from approximately 1945 to 1955. A disposal area where shell casings, OE scrap, and debris that had been dug out from the test tunnels were discarded is believed to have been adjacent to and northeast of the entrance to the tunnels.

All structures within the Howitzer Test Facility have been dismantled. Most of the building construction debris and inert OE scrap was removed from the Project Site during these activities. A large number of concrete-filled howitzer shells were unearthed during the dismantling activities in 1996, particularly in the vicinity of the test tunnels.

During the initial site preparation activities, gravel/debris was removed from inside the test tunnels. The soil cover over the concrete tunnels was also removed, and the tunnels and other structures in the area were dismantled. The removed gravel/debris and soil were screened under the observation of a qualified explosives specialist. The debris from inside the tunnels consisted primarily of gravel and howitzer shells filled with pea gravel or plaster and inert scrap. Some non-DOD-related debris was also removed (e.g., a burned-out car).

The soil removed from over the tunnels also contained gravel- or plaster-filled howitzer rounds. The gravel/debris and soil were screened for OE, and as much as possible were sorted into two stockpiles. One soil stockpile was relatively free of OE scrap; the other had gravel and small fragments of OE scrap. As dismantling activities continued, OE scrap (inert ordnance and spent fuzes) was found beneath Building 540. The Howitzer Test Facility area was geophysically mapped, and all observed anomalies were investigated and removed. Excavated and screened soil from the OE clearance activities was also placed in the soil stockpile. The two stockpiles were subsequently moved around the Howitzer Test Facility area to accommodate a complete geophysical survey of the area. The two stockpiles were eventually consolidated into a single stockpile (Stockpile #3). No live OE items resulting from the howitzer test activities have been reported or discovered.

1.5.4.3 North Valley Military Landfill.

Based on historical information, the disposal area referred to as the North Valley Military Landfill is thought to have existed in the North Valley, just east of the Howitzer Test Facility. The disposal area was apparently first used when the tunnels were constructed in 1945 and was in operation until approximately 1955, when the testing activities ceased. The area was originally a poorly defined drainage pathway that was reported to have been gradually filled with shell casings, inert scrap, and debris dug out of the test tunnels after artillery testing. During the 1996 initial site preparation activities at the Howitzer Test Facility, an area of debris consisting of wood crates, wood pallets, and packing materials was encountered northeast of the previously estimated disposal area to a depth of no more than 5 feet bgs. Some inert ordnance, including practice 155-millimeter (mm) howitzer rounds (gravel or plaster-filled), was also recovered

and removed from this area during the OE clearance of the Howitzer Test Facility. The wood debris and packing materials were added to the screened soil stockpile and eventually consolidated into Stockpile #3. No live OE has been reported or discovered in the suspect landfill area.

In May 2000, the landfill was investigated as part of the site RI. During this investigation, the landfill was investigated using back hoe-excavated test pits. Each test pit was cleaned of metallic anomalies by OE technicians. Approximately one-half of the anomalies investigated were classified as OE scrap. No live OE items were recovered.

1.5.4.4 Ammunition Renovation/Primer Destruction Site.

The Ammunition Renovation/Primer Destruction Site is in the North Valley adjacent to the Howitzer Test Facility. The Primer Destruction Facility and, subsequently, the Ammunition Renovation Facility were at this site.

The Primer Destruction Facility was constructed on a relatively flat surface partially paved with asphalt at the upper reaches of North Valley, near the drainage divide, and was operational from 1945 to 1947. Typically, at primer destruction facilities, primers were destroyed by being dumped and burned in a "squirrel cage," or metal tank. Primers for various munitions were pulled out, removed, and placed onto a conveyor belt, then dropped into a cage and burned. An oil burner was usually attached to the cage or tank and was left running constantly in order to ignite the primers.

The Ammunition Renovation Facility consisted of two wooden buildings and two canvas shelters (Jacobs Engineering, 1999), which were used to inspect and refurbish ordnance items stored at the former Benicia Arsenal. The RRR stated that the area was used for breakdown operations, cleaning, and processing of ammunition casings in preparation for painting (Jacobs Engineering, 1999).

During the 1996 initial site preparation activities, the wooden structures were dismantled and the construction debris removed from the Project Site. Asphalt paving, which partially covered the Ammunition Renovation/Primer Destruction Site, was removed, along with 1 to 2 feet of underlying soil and placed in two stockpiles along the north edge of the Project Site. No OE items were found, and none were expected based on the types of activities conducted in this area.

1.5.4.5 Dynamite Burn Site.

On the Ridge, aged, out-of-service dynamite was reportedly disposed of through burning. Aged dynamite was burned by placing multiple sticks of dynamite in rows up to 100 feet long on a piece of paper and igniting the paper. This area is reported to have been used continuously for 3 months in 1947 and 1948 until all of the dynamite was destroyed (Jacobs Engineering, 1999). Inspection of aerial photographs taken on December 1, 1947, reveals a criss-cross pattern of dark and lighter strips oriented approximately northeast-southwest and northwest-southeast, which is interpreted to represent the burn strips.

The Ridge containing the Dynamite Burn Site was excavated during grading activities associated with the Southampton development in 1990. Based on an analysis of past grading activities, soil from the historical location of the Dynamite Burn Site appears to have been placed as fill at or near the base of the McAllister Drive Land Bridge.

1.5.4.6 Flare Site.

The Flare Site is situated in the South Valley, on the south side of the wetlands, and is visually evident by the residual ash on the ground surface (see Figure 1-3). The inspection of aerial photographs indicates that the site was situated over a landslide evident on the earliest available aerial photographs (1937). The Flare Site was used to dispose of flares by burning them (Jacobs Engineering, 1999). This usually consisted of placing flares on the ground in rows and igniting them. Although no evidence of burning was visible in the aerial photographs, physical evidence of burning (i.e., residual ash) remains at the Flare Site, as observed during recent site visits. It is uncertain if the Flare Site was used to dispose of ordnance. A relatively large number of anomalies is evident in the geophysical data.

1.5.4.7 Demolition Site #1.

Demolition Site #1 is situated near the bottom of the South Valley on the south side of the wetlands (see Figure 1-3). A small drainage runs down the south slope of the South Valley immediately to the east of the suspected demolition site. The site is clearly visible in a number of the historical aerial photographs and first appears circa 1945, although no evidence of the type of use is evident on the photographs. No live ordnance items have been recovered from this site during previous investigations; however, OE scrap and fragments have been recovered around and near the site. The site was included in the sitewide geophysical survey performed by NORCAL Geophysical Consultants, Inc. (NORCAL), in 1997, and a large, magnetic anomaly is evident in the data at the south end of the suspected site. Several smaller anomalies are also evident from the data in the north portion of the site. An electronic copy of the NORCAL geophysical data, the dig sheets, and a summary of the ordnance data are provided as Appendix D.

1.5.4.8 Demolition Site #2.

The area identified as Demolition Site #2 shows little or no evidence of use as a demolition site. The site is on the south side of the South Valley between the Flare Site and Demolition Site #1 (see Figure 1-3). The site appears disturbed or barren in several of the historical aerial photographs. However, disturbance in this area is also associated with a landslide/earthflow identified in that area on the 1945 and later photographs. Review of the sitewide geophysical data does not indicate a high anomaly count, similar to those of Demolition Sites #1 and #3, nor is there evidence of chemically affected soils.

Because there is little or no physical evidence that this site was used as a demolition pit, it has been concluded that this site was not used.

1.5.4.9 Demolition Site #3.

Demolition Site #3 is situated on the north side of the South Valley (see Figure 1-3). Several OE items were recovered from this site both by Granite and USACE (see Appendix D). Also, a half-track armored personnel vehicle was removed from this site, hauled up the north slope of the South Valley, and cut into pieces, which were recycled at a local metal fabrication shop. Demolition Site #3 is evident in the sitewide geophysical data and on the aerial photographs (since 1947); it coincides with a bench cut into the hillside. The topographic map shows the bench cut at an approximate elevation of 105 feet above MSL. The surface of the bench appears disturbed in several of the photographs.

1.5.5 Ordnance and Explosives Type, Composition, Quantity, and Depth Distribution

DOD conducted OE clearance activities in the South Valley in 1955 (U.S. Army Corps of Engineers, St. Louis District, 1994a) in anticipation of disposal of part of the property. However, during a later inspection of the South Valley in 1955, several live OE items were found, and it was recommended that a second clearance be performed. During this inspection, four hand grenades, two 37mm high-explosive (HE) projectiles, three 60mm mortars, and one 75mm (HE) projectile are reported to have been found. No record of a possible second clearance could be found. No other DOD-initiated clearance actions were reported in the RRR (Jacobs Engineering, 1999) and ASR Supplement (U.S. Army Corps of Engineers, St. Louis District, 1997).

The next reported OE clearance activity was initiated when a concrete-filled howitzer shell was encountered during preliminary site preparations in mid-1996. On May 3, 1996, Cal/EPA, DTSC, performed a site visit in response to concerns raised by local citizens about possible hazards on the property due to past DOD-related activities. Following that site visit, DTSC recommended that a thorough investigation of the site be performed, including a Preliminary Endangerment Assessment and an OE Waste Assessment. DTSC also recommended that development activities at the site be curtailed pending completion of the investigation of the site. Granite retained OE experts and initiated OE investigations on the Project Site. The work included geophysical mapping and OE removal.

The initial geophysical surveys at the site were limited to the Howitzer Test Facility and limited dispersed data collection areas across the Project Site. The initial survey areas are shown on Figure 1-4 (areas A through Q). An EM61, a high-resolution, time-domain metal detector, was used to collect data for the initial surveys. In August 1996, an OE clearance was performed at the Howitzer Test Facility using the EM61 data. The clearance was conducted to support the dismantling of the howitzer tunnels and related structures. In addition, areas at the Ammunition Renovation/Primer Destruction Site (Area E on Figure 1-4), and

along portions of the north and east Project Site boundaries (Areas F through O) were investigated and cleared using the electromagnetic (EM) data to identify anomalies and magnetometers to reacquire the points. Appendix D includes a copy of the dig sheets, a summary of the OE data collected from this investigation, and a CD with the raw EM data collected during this investigation. In November 1996, while removing a concrete floor slab from beneath former Building 540, several howitzer dummy 155mm shells and 18 practice land mine fuzes with pins were found. They were inspected by a number of OE specialists and determined to be OE scrap. It should be noted that no OE items were recovered during the August 1996 clearance activities. However, as part of preparing for the Removal Action Investigation, an inventory was taken of the on-site ordnance storage magazine. Two rusted grenade fuzes were stored in the magazine. It is unknown from where these fuzes were recovered. The areas cleared are shown on Figure 1-4.

In fall 1996, NORCAL performed a total magnetic field (TMF) vertical gradient survey to assess the distribution of OE. Appendix D includes a CD with the TMF data collected. This survey consisted of the investigation of contiguous 200-foot by 200-foot grids (as shown on Figure 1-4) utilizing cesium vapor magnetometers arrayed to measure the vertical gradient of the TMF. The magnetometer survey did not include Ridge cut areas where surficial materials had been stripped to bedrock, the west portion of the South Valley, or the wetland in the South Valley.

Approximately 8.5 acres of the Project Site was cleared of OE in December 1996 using the magnetometer data. The identified magnetic anomalies were investigated by excavating the location of the anomaly until an anomaly source was located. When OE was encountered, it was identified and removed. Six OE items were removed from the Project Site in November and December 1996, including two 37mm HE rounds, two 40mm anti-aircraft HE rounds, one 60mm HE mortar shell, and one 76mm armor-piercing HE round. The OE clearance was suspended pending further investigation of the former Benicia Arsenal by USACE. The location of the OE items recovered and the area cleared are shown on Figure 1-4. Appendix D includes the dig sheets and a summary table that lists the depth, location, quantity, and number of anomalies investigated during this clearance activity. A summary of the OE items recovered from the Project Site is presented in Table 1-1

ENGINEERING EVALUATION/COST ANALYSIS INVESTIGATION

USACE conducted an EE/CA investigation for the entire former Benicia Arsenal, including the majority of the Project Site. Portions of the Project Site and adjacent property were geophysically mapped, and subsurface anomalies that were identified were sampled to determine the presence or absence of OE. Two OE items were encountered within the Project Site (one 75mm unfuzed shrapnel projectile and one 37mm fuzed projectile) during the EE/CA field investigation. These items were disposed of by demolition (U.S. Army Engineering and Support Center, 2000). The locations of these items are also shown on Figure 1-4. No OE or OE scrap was recovered from property

immediately adjacent to the north of the Project Site during the EE/CA investigation. Appendix D includes a summary table that lists the depth, location, quantity and number of anomalies investigated.

EE/CA Geophysical Investigation

Twenty-one 100-foot by 100-foot grids (4.82 acres) on the Project Site were investigated using magnetometer data previously collected by NORCAL. For areas where previously collected magnetometer data were not available and to assess the quality of the magnetometer data previously collected, a Geonics EM61 high-sensitivity metal detector was used to detect and map the location of subsurface anomalies and record the geophysical character. A total of 12 grids (2.75 acres) within the Project Site and an additional 7 grids (1.61 acres) immediately adjacent to the Project Site were geophysically mapped using the EM61 (see Figure 1-4).

REMOVAL ACTION WORK PLAN INVESTIGATION (RAW)

The removal action investigation phase of the non-OE RI included clearing anomalies from proposed excavation locations at the North Valley Military Landfill to facilitate the non-OE characterization of soil beneath the landfill. Geophysical techniques were utilized to locate subsurface anomalies within the North Valley Military Landfill. Anomalies identified in the footprint of a proposed exploratory test pit location were intrusively investigated to determine the source of the anomaly and to clear any OE encountered. OE scrap was encountered in approximately one-half of the excavations, although no OE was recovered from the North Valley Military Landfill. Appendix D includes a summary table that lists the depth, quantity, and anomalies investigated during this removal action.

RAW Geophysical Characterization

A Geonics EM61 high-sensitivity metal detector was used to detect and map the location of subsurface anomalies and record the geophysical character. A total of 0.26 acre within the North Valley Military Landfill were geophysically mapped using the EM61. Appendix D includes a CD with the RAW geophysical data.

Other OE finds

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In May 1999, a potentially live expelling charge was encountered in the South Valley during the interim investigation phase of the non-OE RI. The expelling charge was discovered on the surface by UXO personnel that was accompanying the field crew while accessing 1 of 12 proposed test pit locations on the Project Site. The Explosive Ordnance Disposal (EOD) unit from Travis Air Force Base responded and removed the item. No official determination could be made as to whether the expelling charge was live; however, it has been classified as OE for the purpose of this discussion. The location of this item is shown on Figure 1-4.

Distribution of Recovered Anomalies

The majority of OE-related items recovered from the Project Site during previous OE clearances, the EE/CA investigation, and the removal action investigation were classified as OE scrap. OE scrap includes inert items such as gravel- or plaster-filled howitzer rounds, expended 105mm projectiles, and fragments of demolished ordnance. All non-OE-related items found during the previous clearances and investigations were classified as non-OE scrap. These items include, but are not limited to wooden boxes, wire, banding material, trash, and nails. A listing of OE-related items recovered from the Project Site during the August and December 1996 OE clearances, the EE/CA investigation, and the removal action investigation, is provided in Appendix D.

During the OE clearance of the Howitzer Test Facility and dispersed areas across the Project Site in August 1996, a total of 180 anomalies were intrusively investigated. A total of 69 anomalies (39 percent) were classified as OE scrap, and 95 anomalies (52 percent) were classified as non-OE scrap. There were no OE items recovered from the Project Site during the initial clearance in August 1996. A total of 16 anomalies (9 percent) were classified as "unable to locate." An anomaly was classified as unable to locate when either the OE dig team could not reacquire a magnetic signal at the location specified in the data collected by the geophysical investigation team or when a magnetic signal was reacquired and intrusively investigated, no magnetic source was found.

During the OE clearance conducted in December 1996, a total of 1,182 anomalies were identified at the Project Site and intrusively investigated. A total of 3 anomalies (less than 1 percent) were classified as OE, 842 anomalies (71 percent) were classified as OE scrap, and 337 anomalies (29 percent) were classified as non-OE scrap. In addition, three OE items were recovered from the Project Site in November 1996 prior to the December clearance activities. During the RAW investigation, two rusted grenade fuzes were noted in the inventory for the existing on-site magazine. The available dig sheets from previous investigations do not list the fuzes. Most likely, the grenade fuzes were recovered and placed in the magazine during the November/December clearance activities.

Of the 274 anomalies intrusively investigated at the Project Site during the EE/CA investigation and determined to be associated with OE or OE scrap, 233 (85 percent) were recovered at depths ranging from 0 to 12 inches (i.e., within the first foot). A total of 36 anomalies (13 percent) were recovered at depths ranging from 12 to 24 inches. A total of four anomalies (1 percent) were recovered from between 24 and 36 inches, and one anomaly (less than 1 percent) was recovered at a depth of 48 inches.

The nine OE items recovered from the Project Site were found at depths ranging from 0 to 2 feet bgs. All OE scrap recovered from the Project Site, outside of the demolition pits, were recovered at depths of 2 feet bgs or less, with the following exception. Two grids (Grids 0313 and 0311) outside the demolition pits were found to contain OE scrap at depths up to 3 feet and 4 feet bgs, respectively. These grids were adjacent to areas disturbed by grading activities that may

have dumped various amounts of fill over the area. The absence of OE scrap at depths greater than 2 feet bgs, except as noted above and the actual demolition pits, indicates that any OE at the Project Site would be shallowly buried. Penetration depth of OE at the site is unlikely to be associated with ballistic trajectories. All subsurface OE has been buried either by natural processes or by man. Using the impact velocities for various force-fall heights ranging from 50 to 500 feet, the maximum penetration depth in clayed soil for 37mm projectiles would be 0.187 inch to 1.81 inches. Similarly, the maximum penetration depths for a 60mm projectile would be 0.267 inch to 2.59 inches (Estimating Ordnance Penetration into Earth, CEHNC-ED-CS-S [Appendix E]). The depth of soil penetration by soil type for a 37mm projectile and a 60mm mortar is shown in Table 1-2

1.5.6 Off-Site Issues

The draft final RI/FS for the Project Site identified two potential off-site issues: (1) TNT-affected soil may exist off site to the east and/or north of the TNT Strips, and (2) off-site fill areas. As noted in the draft final RI/FS, the areas where it is expected that soils may contain 10 percent or more explosives by weight have been included within the Project Site boundary and will be remediated along with the on-site TNT Strips. Soil and bedrock that was originally located within the Project Site boundary was moved in 1990 during grading activities. A portion of the soil and bedrock was used to construct the on-site land bridge. In addition to the on-site uses, these materials were used as fill in residential subdivisions south and southwest of the Project Site. It is not known if the soil transported off site contained OE and/or OE scrap.

On August 10, 2000, a Benicia resident reported to local authorities that he had encountered an ordnance-related item on his property. Granite's OE Specialist and USACE have inspected the item and have come to the following conclusions:

- The tail fin is from a mortar.
- The condition of the tail fin indicates that the mortar was destroyed by demolition.
- The mortar had not been fired as evidenced by the unpierced percussion primer at the base of the tail fin.
- Given that no firing ranges have been identified at the former Benicia Arsenal, the likely point of origin for the tail fin was an open burn/open detonation (OB/OD) site.
- The tail fin has been determined to be OE scrap.
- A total of 15 tail fins were found during the EE/CA investigation; 5 of these items were recovered in Sector 3B (a portion of the Project Site) and 10 were recovered in Sector 5 (the Camel Barn area). USACE designated all these items as OE scrap.

- The tail fin is nonhazardous and does not pose a safety risk.

- There is currently no basis to believe that a dangerous condition exists at the residential lot.

- At this time, additional information is needed to assess the likelihood that OE items exist in areas that have previously received fill soils.

Discussions have occurred between DTSC, USACE, and Granite concerning future activities that are appropriate to address the off-site issue. The following three points have resulted from these discussions:

- During the clearance work to be conducted at the Project Site and the former Benicia Arsenal (the Gonzalves property), additional information regarding potential source areas and the distribution of OE and OE scrap will be obtained. This information, combined with existing information, will be evaluated by DTSC, USACE, and Granite and will be used to determine if further action is warranted.

- USACE is currently developing a Community OE Safety Program. The program focuses on educating the City of Benicia emergency staff on ordnance recognition, proper safety procedures and notification, community education through workshops for adults and children, fact sheets, and newsletters.

- The final site conceptual model will be based on data collected during the point clearance phase of the OE investigation and remediation at the Project Site, which is scheduled to begin in late fall 2001, and during the work at the former Benicia Arsenal, which began in May 2001. Evaluation of the data may be available in the first quarter of fiscal year 2002. Based on the final site conceptual model and consistent with USACE procedure, if DTSC determines that OE was distributed to residential areas outside the Project Site boundary and as a result there is risk that OE items can be encountered in a manner presenting a significant risk of injury or death, then concurrent with the areawide clearance phase of work activities, a plan will be developed in accordance with an order or agreement to identify and address these off-site areas. This plan will be presented to the public. If required, the plan will include an analysis of response alternatives for these areas. Response alternatives may include the development of a Community Awareness Plan to educate the public, institutional controls, surface clearance of OE, and/or detection and clearance of OE to depth.

1.5.7 Current and Future Land Use

The Unit D-1 portion of the site, which is south of the South Valley, has been graded for residential development, with streets and utilities installed. One unoccupied house has been constructed in the Unit D-1 area.

The South Valley remains relatively undisturbed, except for the past activities previously described. The Ridge was used as a soil borrow area and, subsequently, as a soil stockpile area. As described above, the bottom of the North Valley has had a number of buildings installed and subsequently removed.

The Ridge, a majority of the North Valley, and Unit D-1 areas are planned as a residential development. The South Valley will remain as open space (Figure 1-5).

1.5.8 Man-made Features Potentially Affected by Removal Actions

The Ridge was used as a borrow area. Aerial photographs of the area indicate that some of the removed soils were used to construct the McAllister Drive Land Bridge. A sewer bench runs on the south slope of the South Valley parallel to a portion of Unit D-1. The sewer bench was constructed by cutting and filling and, therefore, the fill areas along the sewer bench may contain soils affected by OE. Additional fill areas within the Project Site where OE-affected soil may have been used as fill include fill areas in Unit D-1, the McAllister Drive Land Bridge, several landslide repair areas, and minor amounts of fill soils in the bottom of the North Valley. Soils in these areas will be cleared of OE through point clearance or point clearance and areawide clearance during the remedial action to ensure that no OE/pathway remains for interaction with the public.

1.6 Ordnance and Explosives Remedial Design Document Format

This document is organized as follows:

- **Chapter 1.0 - Introduction:** Discusses the OE remedial design goals and objectives, regulatory oversight, site physical features, site history, off-site issues, and current and future land use.

- **Chapter 2.0 - Remedial Design:** Provides a summary of the site ordnance and explosives remediation, descriptions of sub areas of the site to be investigated, and the sequence of work activities.

- **Chapter 3.0 - Design Basis:** Details the basis for the OE remedial design and describes the extent of the OE removal/remediation, site safety, environmental controls, regulatory considerations, public safety, technical approach, and data management for the detection and removal of OE.

- **Chapter 4.0 - Fieldwork:** Describes the detailed fieldwork required to implement the OE remedial design and criteria defined in Chapter 3.0, using the sequence of work outlined in Chapter 2.0.

- **Chapter 5.0 - Project Closure:** Describes the demobilization activities and preparation of the Project Site Closure Reports and Operation and Maintenance Plans.

- **Chapter 6.0 - Quality Control Plan:** Defines the roles and responsibilities for the quality assurance (QA)/quality control (QC) of the OE remediation activities and establishes procedures for QA/QC for the OE remediation.

- **Chapter 7.0 - Remedial Design Management Plan:** Identifies the Project Management organization including regulatory oversight and describes community outreach activities including key points of contact.

- **Appendix A - Project Schedule:** Includes the schedule for the fieldwork.

- **Appendix B - Minimum Separation Area Notification and Implemention:** Provides the procedures for public notification of project activities and establishes procedures for the evacuation of personnel from areas during hazardous operations..

- **Appendix C - Explosives Safety Submission:** Includes the Explosives Safety Submission to the Department of Defense Explosives Safety Board (DDESB).

- **Appendix D - NORCAL Geophysical Data:** Provides hard-copy and electronic copies of the data developed by NORCAL's 1996 geophysical mapping.

- **Appendix E - Estimating Ordnance Penetration into Earth:** Provides the methodology used by USACE for determining ordnance penetration into Earth.

- **Appendix F - Ordnance and Explosives Site-Specific Health and Safety Plan:** Provides the health and safety standards and procedures to be followed for all personnel accessing the Project Site during the OE remediation.
- **Appendix G - Minimum Separation Distance Calculations:** Provides the USACE letters of approval and calculations used to establish minimum separation distances (MSDs) for conducting OE clearance activities on the Project Site.

- **Appendix H - Earth Tech Field Forms:** Includes reproducible copies of the field forms to be used during the OE remediation.

- **Appendix I - Standard Operations Procedures - Demolition/ Disposal Operations:** Provides the detailed operating procedures for preparation, demolition, and disposal of OE found on the Project Site during the remediation activities.

- **Appendix J - Blow-in-Place Engineering Controls:** Describes the engineering controls to be used for the preparation of OE items to be destroyed in-place without relocating them to the designated demolition/disposal area.

- **Appendix K - MTADS Standard Operating Procedures:** Provides the methodology to be used for operation Multi-sensor Towed-Array Detection System (MTADS) on the Project Site.

- **Appendix L - Resumes:** Includes resumes of key personnel.

- **Appendix M - References:** Includes the list of references used to prepare the OE RDD.

Table 1-1. Summary of OE Found on the Tourtelot Property

Grid	Easting[a]	Northing[a]	Type	Description	Depth (inches)	Disposition	Date Found
NA[b]	6518714	1792353	OE	37mm HE projectile	unknown	Destroyed by Travis AFB EOD Unit	11/12/96
NA[b]	6518717	1792344	OE	76mm APHE round	unknown	Destroyed by Travis AFB EOD Unit	11/12/96
NA	6519242	1792111	OE	37mm HE projectile	unknown	Destroyed by Travis AFB EOD Unit	12/96
I-14	6519030	1792468	OE	40mm AA HE	12	Destroyed by Travis AFB EOD Unit	12/02/96
O-15	6520319	1792264	OE	60mm mortar, fuzed	2	Destroyed by Travis AFB EOD Unit	12/05/96
P-15	6520425	1792250	OE	40mm AA, unfired	8	Destroyed by Travis AFB EOD Unit	12/06/96
0312	6518714	1792342	OE	37mm HE projectile, fuzed	24	Destroyed on-site	02/23/99
0312	6518710	1792352	OE	75mm shrapnel HE projectile, unfuzed	6	Destroyed on-site	02/23/99
NA	6519085	1792150	OE	Expelling charge	surface	Destroyed by Travis AFB EOD Unit	05/06/99

Notes: (a) Easting and northing coordinates are estimated based on the location of the item within the sampling grid.
(b) Item found in EE/CA grid 0312, prior to the 1999 EE/CA investigation.

AA = anti-aircraft
AFB = air force base
APHE = armor-piercing, high explosive
EOD = explosives and ordnance disposal
HE = high explosive
NA = not applicable
OE = ordnance and explosives

Table 1-2. Depth of Penetration (inches) for a 37mm Projectile Based on Soil Type[(a)]

Height (feet)	Limestone	Sandy Soil	Vegetated Soil	Clay Soil
37mm Projectiles				
50	0.014	0.093	0.123	0.187
100	0.027	0.186	0.245	0.373
150	0.041	0.278	0.366	0.558
200	0.054	0.370	0.486	0.741
250	0.067	0.461	0.605	0.923
300	0.081	0.551	0.724	1.104
350	0.094	0.640	0.841	1.283
400	0.107	0.729	0.958	1.461
450	0.120	0.817	1.074	1.638
500	0.133	0.905	1.189	1.814
550	0.145	0.992	1.304	1.988
600	0.158	1.079	1.417	2.161
650	0.171	1.164	1.530	2.333
700	0.183	1.250	1.642	2.504
750	0.195	1.334	1.753	2.674
800	0.208	1.419	1.864	2.843
850	0.220	1.502	1.974	3.010
900	0.232	1.585	2.083	3.176
950	0.244	1.668	2.191	3.342
1,000	0.256	1.750	2.299	3.506
60mm Mortar				
50	0.020	0.133	0.175	0.267
100	0.039	0.266	0.349	0.532
150	0.058	0.397	0.522	0.796
200	0.077	0.528	0.693	1.057
250	0.096	0.657	0.863	1.317
300	0.115	0.786	1.032	1.574
350	0.134	0.913	1.200	1.830

Table 1-2. Depth of Penetration (inches) for a 37mm Projectile Based on Soil Type[(a)]

Height (feet)	Limestone	Sandy Soil	Vegetated Soil	Clay Soil
60mm Mortar (cont'd)				
400	0.152	1.040	1.366	2.084
450	0.171	1.166	1.532	2.336
500	0.189	1.291	1.696	2.587
550	0.207	1.415	1.859	2.835
600	0.225	1.538	2.021	3.083
650	0.243	1.661	2.182	3.328
700	0.261	1.785	2.342	3.572
750	0.279	1.903	2.500	3.814
800	0.296	2.023	2.658	4.054
850	0.314	2.142	2.815	4.293
900	0.331	2.261	2.970	4.530
950	0.348	2.378	3.125	4.766
1,000	0.366	2.495	3.278	5.000

Note: (a) Depth of penetration calculations do not account for air friction.
mm = millimeter

Figure 1-1

Figure 1-2

Figure 1-3

Figure 1-4

Figure 1-5